ABSTRACT

The invention provides HF vapor process conditions that can be precisely controlled with a high degree of reproducibility for a wide range of starting wafer conditions. These HF vapor processes for, e.g., etching oxide on a semiconductor substrate, cleaning a contaminant on a semiconductor substrate, removing etch residue from a metal structure on a semiconductor substrate, and cleaning a metal contact region of a semiconductor substrate. In the HF vapor process, a semiconductor substrate having oxide, a contaminant, metal etch residue, or a contact region to be processed is exposed to hydrofluoric acid vapor and water vapor in a process chamber held at temperature and pressure conditions that are controlled to form on the substrate no more than a sub-monolayer of etch reactants and products produced by the vapor as the substrate is processed by the vapor. The sub-monolayer HF vapor process regime is defined in accordance with the invention to proceed under conditions wherein no more than about 95% of a monolayer of coverage of the substrate surface occurs.